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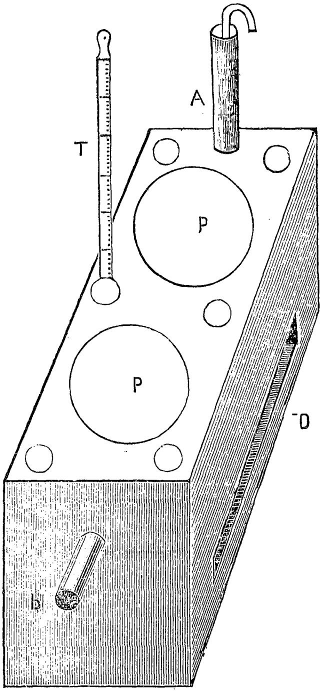
WATER BATH.



The diagram represents a convenient form of water bath, devised by Dr. Mayer.

It is a small brass box 18^{cm} long, 9^{cm} wide and 8^{cm} high. The tube *a*, through which the water is received, and the rod *b* serve as handles. The receiving tube is closed by a cork provided with a glass tube for the escape of steam, which is bent in the form of a siphon to protect against dust. One and a-half centimeters from the base of the box is an oven (*o*) $.7^{cm}$ high, and 12^{cm} long, which passes completely through the box, and serves for warming the slides when shellac is used. Above are seen two circular basin-like pits (*p*) 5.5^{cm} in diam., and 4^{cm} deep, for receiving the two tin paraffine holders. These are covered by circular plates of glass. There are also six tubular pits, one for a thermometer (*t*), the others for glass tubes.

This water bath will be found useful for other purposes than those of imbedding and mounting. It will of course be understood that the purpose in giving its exact dimensions is simply to furnish a guide where one is required. There are at least two important advantages offered by this water bath over those in general use, viz., the slides are protected from dust, and the paraffine is not exposed to the water.

——:o:——

ON THE HOMOLOGIES OF THE CRUSTACEAN LIMB.

BY A. S. PACKARD, JR.

THE following observations are reprinted from an essay on North American Phyllopod Crustacea, contributed to the forthcoming Twelfth Annual Report of the U. S. Geological and Geographical Survey of the Territories, F. V. Hayden in charge. I am indebted to Dr. Hayden's kindness for the use of the illustrations—Messrs. Sinclair & Son having, at their own expense, kindly struck off an edition of the accompanying plates from the drawings on stone made by them for the Survey.

The reader is supposed to have a general knowledge of Crustacea, especially the Phyllopods, a brief account of which may be found in the author's Zoölogy, where the genera here referred to are figured. As to the anatomy of these interesting Crustacea, a transverse section of the anterior part of the body of any genus of Phyllopods (see Pl. XII, Fig. 2, also Fig. 1 in text) will convey an excellent idea of the leading features in their organization, especially those by which they differ from the members of other Crustacean orders. The leading topographical features in the body, particularly of Arthropods, are the form of the elemental segments with their appendages, and the relations of the principal anatomical systems to the body-walls.

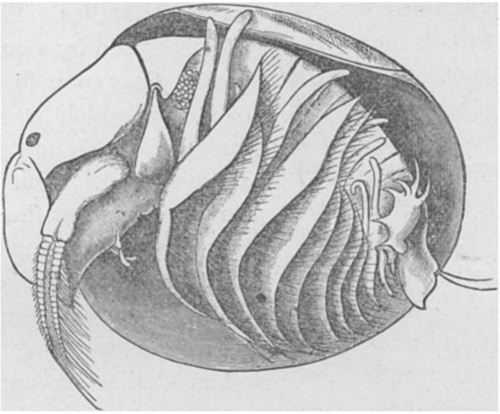


FIG. 1.—*Limnetis brevifrons*, enlarged. Burgess, del.

General relations of the systems of organs to the body-walls.—We will first look at a section of a typical Phyllopod, such as *Apus* (Fig. 2). The body-walls are rather thick and the muscles are well developed, particularly the dorsal extensor muscles, and the motor or extensor muscles of the limbs, which arise in part from the dorsal region, and in part from the sides and sternal region. The body cavity is rather small. The heart is large, either cylindrical as in Estheria, or flattened as in *Thamnocephalus.* The digestive tract is large, capacious, and the cavity of the head is mainly filled with the two liver masses; the brain being remarkably small, while the nervous cord, especially the second and succeeding ganglia, are remarkably small and weak, compared with other

Crustacea, either the malacostracous or the entomostracous orders; this peculiarity is well brought out in the transverse sections, where the diminutive size of the thoracic ganglia, particularly in *Limnetis* and *Estheria* is noteworthy. The apparent bulk of the body is largely due to the large size and nature of the leaf-like or foliaceous appendages, with their broad attachments; the latter peculiarity is characteristic of the Branchiopods in general and the Phyllopods especially, and is quite different from the definite, small coxal articulations of the legs of Malacostraca or Copepoda. The ovaries or testes, according to the sex, form a large lobulated mass extending along each side of the digestive canal, as far forward as the base of the head. Their relations in *Apus* are seen in Plate XXII, Fig. 2, and in *Thamnocephalus* in Plate XIV, Fig. 4 of our essay.

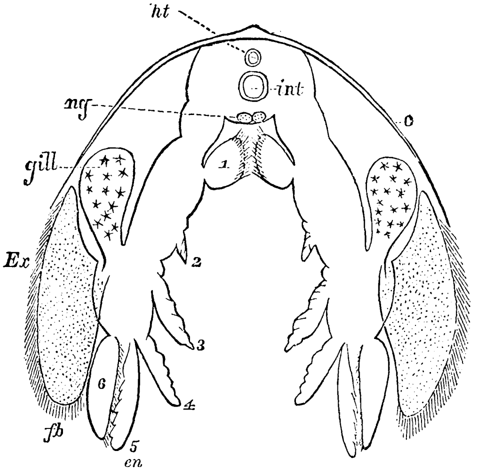


FIG. 2.—Section of Apus; *ht*, heart; *int*, intestine; *ng*, ganglion; *c*, carapace; 1–6, the six exites, 1 being the gnathobase; *gill* and *fb*, flagellum, representing the exites.

The segments of the body.—Phyllopoda are exceptional to other Crustacea in having an indefinite number of segments composing the body, and in having in one family (*Apodidæ*) more than one pair of appendages to an arthromere. While the normal number in the Decapoda is twenty-one, in the Phyllopods it varies from seventeen in Limnetis to forty-seven in Apus. The following table shows the number in different genera of American species:

	Antennal segments.	Mandibles.	Maxillæ.	Maxillipedes.	Limb segments.	Abdominal segments.	Telson.	Total.
Limnetis	2	1	1	....	12 (–14)	0	1	17–10
Estheria	2	1	2	....	23–27	0	1	29–33
Limnadia	2	1	2	....	1 22	0	1	28
Apus	*2	1	1	†1	27 (66 pairs limbs)	32 (14)	1	47
Artemia	3	1	2	0	11	8	1	25
Branchinecta	2	1	2	0	11	9	1	26
Branchipus	2	1	2	0	11	9	1	26

* Second antennæ sometimes wanting.

† The endite of *Apus* wanting in the American species.

In an *Apus lucasanus* forty-two millimeters in length there are sixty pairs of legs behind the maxillipedes. There are forty-two segments behind the maxillipedal segment, including the telson, and twenty-seven limb-bearing segments, or sixty pairs of legs to twenty-seven segments, the average being two and six-twenty-sevenths ($2\frac{6}{27}$) appendages to each leg-bearing segment. On the first eleven leg-bearing arthromeres, or the ten thoracic legs (bænomeres) together with the first abdominal arthromere, there is but a single pair of appendages to a segment, so that there are forty-nine pairs of abdominal appendages to sixteen arthromeres, or three and one-sixteenth pair of limbs, on the average, to each abdominal arthromere. The fourteenth, fifteenth and sixteenth pairs are situated on two arthomeres, and so on with the succeeding until the limbs become more numerous. On the two arthromeres before the last leg-bearing one, there are twelve pairs of appendages, or six to each arthromere.

This irrelative repetition of arthromeres is only paralleled in one other Branchiate group, the *Trilobita.* In this group the new segments are interpolated between the head and abdomen at successive molts, as shown by Barrande.

The grouping of the body segments into a cephalothorax and abdomen, comparable with those two regions in the Decapoda is but slightly, if at all, indicated in the Phyllopoda. In *Limnetis* there is no such distinction of regions, in Apus the cephalothorax merges insensibly into the abdomen, and it is not until we ascend to the *Branchiopodidæ* that we meet with a well-marked abdomen separated by tolerably clear indications from the thorax.

The Appendages in general.—The appendages of Crustacea may be divided into four groups: First, the sensory appendages, or antennæ, which are in the adult preoral; second, the organs of prehension of food and of mastication, *i. e.*, the mandibles and accessory jaws, or maxillæ and maxillipeds, which are postoral; third, organs of locomotion, whether natatorial or ambulatory, which are appended to the thoracic portion of the body; and fourth, the appendages of the abdomen, which are both natatorial and concerned in reproduction; of the latter are the two pairs of gonopoda[1] in the Decapoda, while the eleventh pair of appendages in Apus may perhaps be regarded as gonopods.

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[1] I have (AMERICAN NATURALIST, XV, p. 881, 1881) applied the term *gonopoda* (Gr. γονή, generation; πούς, ποδος, foot) to the first and second abdominal limbs

The following table will give our idea as to the succession and nomenclature of the appendages in the three subclasses of Tracheata and the two subclasses of Branchiate Arthropods:

TABLE A.

Number of segments.	Hexapoda.	Arachnida.	Myriopoda.	Crustacea (neocarida decapoda).	Merostomata. (Limulus.)
1	Antennæ.	Mandible.	Antennæ	First antennæ . .	First (preoral) leg.
2	Mandibles	Maxilla (chela). .	" Maxilla". . . .	Second antennæ .	Second (postoral) leg.
3	First maxillæ . . .	First leg.	"Mandible" . . .	Mandibles	Third pair legs.
4	Second maxillæ (labium.)	Second leg	" Labium " . . .	First maxillæ . .	Fourth pair legs.
5	First thoracic legs (bænopods).	Third leg.	First pair of legs .	Second maxillæ .	Fifth pair legs.
6	Second thoracic legs (bænopods).	Fourth leg	Second pair of legs	First maxillipedes	Sixth pair legs.
7	Third thoracic legs (bænopods).	Embryonic, deciduous.	Third pair of legs	Second maxillipedes.	First abdominal legs.
8	First embryonic deciduous legs.*	. . do.	Fourth pair of legs	Third maxillipedes	Second abdominal legs.
9	Second embryonic deciduous legs.	. . do.	Fifth pair of legs .	First pair of legs . (bænopods).	Third abdominal legs.
10	Third embryonic deciduous legs.	. . do	Sixth pair of legs	Second pair of legs (bænopods).	Fourth abdominal legs.
11	Fourth embryonic deciduous legs.	First pair spinnerets.	Seventh pair of legs.	Third pair of legs (bænopods).	Fifth abdominal legs.
12	Fifth embryonic deciduous legs.	Second pair spinnerets.	Eighth pair of legs	Fourth pair of legs (bænopods).	Sixth pair abdominal legs.
13	Sixth embryonic deciduous legs.	Third pair spinnerets.	Ninth pair of legs.	Fifth pair of legs (bænopods).	
14	First pair of rhabdites.†	Telson of scorpion.	Tenth pair of legs.	First abdominal legs (uropods).	
15	Second pair of rhabdites.	. . . .	Eleventh pair of legs.	Second abdominal legs (uropods).	Telson (spine).
16	Third pair of rhabdites.	. . . .	Twelfth pair of legs.	Third abdominal legs (uropods).	
17	Cercopoda of some Orthoptera and Neuroptera, and anal legs of caterpillars.	. . . .	Thirteenth pair of legs.	Fourth abdominal legs (uropods).	
18	Eleventh abdominal segment in some Orthoptera and Pseudo-neuroptera.	. . . .	Fourteenth	Fifth abdominal legs (uropods).	
19	. . . .	. . . .	Fifteenth	Sixth abdominal legs (uropods).	
20	. . . .	. . . .	Sixteenth; 200th in Geophilus.‡	Telson	

* See Kowalevsky, Embry, Studien an Wurmern und Arthropoden, 1871, Plate XII, Fig 10. Embryo of *Sphinx populi*, in which the first ten abdominal segments have temporary rudimentary appendages, some of which persist in the caterpillar, serving as prop.legs.

† The ovipositor of insects, as we originally pointed out in 1868 (Proc. Boston Soc. Nat. Hist., XI, 393), is primarily composed of three pairs of appendages (called by Lacaze-Duthiers "rhabdites"), which arise in the same way as the legs; this view has been confirmed by Ganin, Kraepelin and Dewitz

‡ The number of movable segments in the Geophilidæ, according to Newport, varies from about 35 to more than 200.

of the Decapoda, which are, as is well known, modified into accessory generative organs. The term is suggested as a convenient one to use in descriptive carcinology when speaking of either or both pairs of the basal abdominal limbs of the male Decapod. In the female they are not modified.

Camparison wth limbs of Cladocera.—We should naturally first compare the appendages of the Phyllopods with the members of their own order, and especially the *Cladocera;* and here, whether we consider the carapace-valves, the eyes single and compound, the two pairs of antennæ, or the telson, we find a very close connection in form between *Limnetis* and *Daphnia* or *Moina.* In the accompanying sketch (Fig. 3) from Gruber and Weismann's excellent paper on the Daphnidæ[1] (which we have slightly modified, introducing dots in the branchial portion) may be seen how nearly the first leg of the male of *Moina rectirostris* agrees with that of the male *Limnetis*, as seen in the sixth endite forming a claw like that of *Limnetis*, although the flabellum is not clearly differentiated from the endopodal portion of the limb. But when we look at the third pair of limbs of the female of the same Cladoceran (Fig. 4), we find an epipodal portion (flabellum, *ex*, and gill) differentiated from the endopodal portion of the limbs. The endopodal portion in the *Cladocera* is not differentiated, and forms a number of well-marked lobes or endites (Lankester), as in the Phyllopoda; this differentiation into six endopodal lobes being peculiar to the *Phyllopoda.*

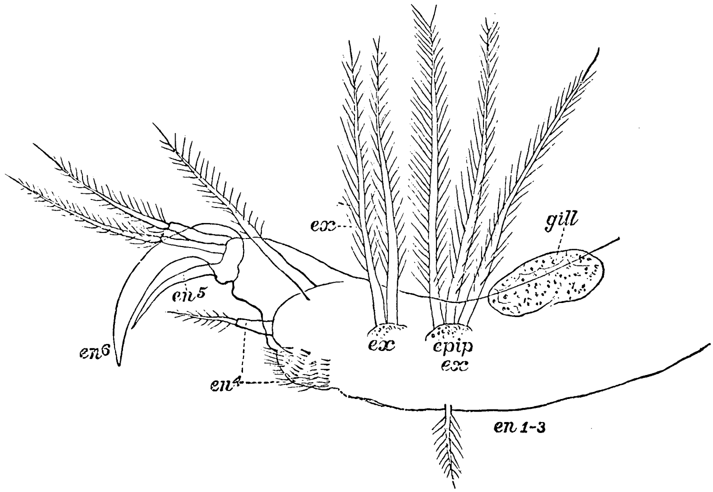

FIG. 3.—First leg of male of Moina (for comparison with that of male Limnetis): *ex*, exite; *epip*, epipodal portion of limb; en^4–en^6, endites, 4–6 compare with the endites forming the hand of the male Limnetis. The base of the endopodal region (*en* 1–3) not differentiated as in the Phyllopod limb.

The Cladocerous limb is intermediate in form and complication between the Phyllopodous and Ostracodous limbs, and the latter are evidently derived from the Copepods, so that there is a continuous ascending series from the Copepoda through the Ostracoda to the Cladocera, and thence to the Phyllopoda. Hence, as the young of the Copepoda are all Nauplii, and also those of the Phyllopoda, it follows that the ancestral form of all the Entomostracous Crustacea, as originally insisted on by Fritz Müller (Für Darwin) was a nauplius-like animal.

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[1] Ueber einiger neue oder unvollkommen gekannte Daphniden. 1877.

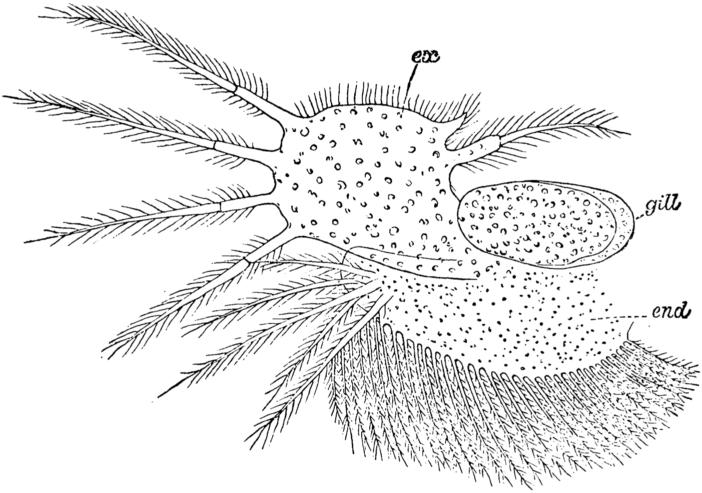

Fig. 4.—One of the third pair of limbs of Moina: *end*, the endopodal portion; *ex*, the exopodal (epipodal) portion of the limb.

Comparison with the Decapodous limbs.—Having studied the homologies of the Phyllopodous limbs among themselves, and also compared them with those of the Cladocera and Ostracoda, it remains now to compare the thoracic appendages of the Phyllopods with those of the adult *Decapoda*. At the outset, however, it seems nearly impossible to compare the swimming legs of the Phyllopods with the abdominal and thoracic appendages of Decapods. The thoracic Decapodous legs are axially jointed, consisting of an axis or protopodite, which is wanting in the Phyllopoda and all lower Crustacea, with no endital lobes as in Phyllopods, though the gill and flabellum of the Phyllopods are homologous with the gills and flabellum of the Decapod. There is no such relation or close resemblance as to lead us to infer that as regards the nature of the thoracic and abdominal feet the Decapods have descended from the Phyllopods. The Decapods have probably come down to us by a different branch of the Crustacean ancestral tree, and have arisen entirely independently of the Phyllopodous branch, by a line leading back directly to the ancestral Nauplius, the common ancestor of all the *Neocarida.*

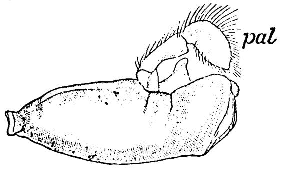

Fig. 5.—Mandible of the lobster, *Homarus americanus*: *pal*, palpus.

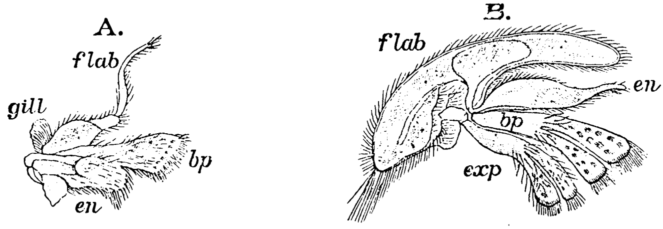

Fig. 6.—A, first maxilla of lobster; *en*, endopodite; *bp*, basipodite; *flab*, flabellum. B, second maxilla of lobster; *bp*, basipodite (epignathus); *cxp*, coxopodite. (This appendage, with its five endopodal lobes, approximates nearest to the Phyllopod limb.)

Nor does it seem to us that this statement or hypothesis is weakened when we consider the resemblances between the thoracic feet of the Phyllopods and the maxillæ and maxillipedes of the Decapoda. When we compare the leg of a Phyllopod with the second maxilla[1] of the lobster (Fig. 6, B) or crayfish, we can detect a close homology, the chief difference being in the fact that the lobes of the endopodite are less numerous in the Decapod than in the Phyllopod. This close resemblance is based on the fact, which appears to have been overlooked by Claus and Lankester, *i. e.*, that as in the Phyllopodous limb, the maxillæ of the Decapods have no jointed axis, the limb consisting of epipodal and endopodal portions alone, the stem or axis being wanted. In the maxillipedes, where part of the endopodal region of the limbs becomes, as Lankester[2] claims, two multiarticulate endites, the fifth and sixth; or, as in the thoracic leg, becomes a single seven-jointed endite, the homologies cannot with certainty be traced. The lobster's thoracic leg consists of the jointed axis which is the homologue of perhaps the fifth endite of the Phyllopodous foot (Lankester), and the complicated gills and gill-fan (scaphognathite) correspond to the gill and flabellum of the Phyllopodous leg or flabellum.

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[1] The resemblance to the second maxillæ of the young lobster in its first stage when freshly hatched, is still more striking. See Smith's Early stages of the Amercan Lobster, Pl. XVI, Fig. 4.

[2] See his able article on the morphology or Apus, *Quart. Journ. Mic. Science*, 1881.

In brief, the maxillæ of the Decapoda most closely resemble the legs of Phyllopods. The maxillipedes, for example, those of the third pair, are much more differentiated than the limbs of the Phyllocarida or Phyllopoda. In the Decapoda the gill and flabellum are homologous with those of the groups just enumerated; while the endopodite and exopodite of the Decapoda represent the endopodal portion of the limb of the lower groups. There is in the Phyllopoda no division into a coxopodite and basipodite or stalk, from which two axially jointed divisions branch off,

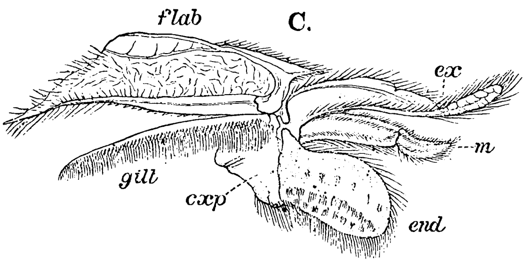


FIG. 7.—C, first maxillipede of lobster.

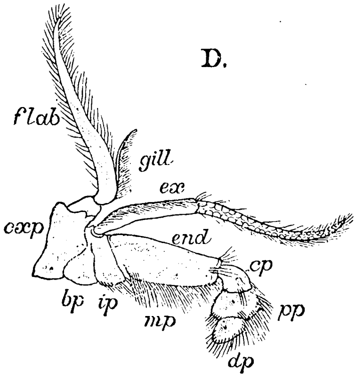


FIG. 8.—D, second maxillipede; *ex*, exopodite; *end*, endopodite; *flab*, epipodite or flabellum, or scaptogathnite.

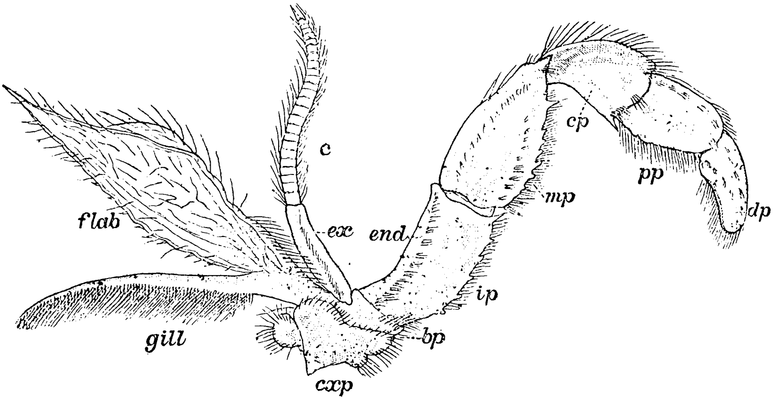


FIG. 9.—B, third maxillipede, *cxp*, coxopodite; *bp*, basipodite; *ip*, ischiopodite; *mp*, meropodite; *cp*, carpopodite; *pp*, propodite; *dp*, dactylopodite; *c*, multiarticulate extremity of exopodite or palpus; *flab*, epipodite.

homologous with the exopodite and endopodite of the Decapoda. In the latter the maxillipede is highly differentiated; in the thoracic limbs of the Phyllocarida and Merostomata it is uniaxial and jointed, but in the Phyllopoda not truly jointed. In the simplest Decapod limb, that of the abdomen, we have a stem succeeded by two divisions, the exopodite and endopodite; in the thoracic feet we have but one of these branches, the endopodite, while in the maxillipedes, the most differentiated, we again have a stem and two branches (endopodite and exopodite), together with the gill and flabellum. Thus the entire leg of the Phyllopod (without the gill and flabellum) is homologous with the endopodite of the Decapod maxillipede, and the gill and flabellum with those of the Decapoda.

Comparison with the thoracic limbs of Nebalia (Phyllocarida).—Not to enter into detail, by a glance at Plate x and the figures in Plate XIV, it will be seen that the thoracic appendages of *Nebalia* consist of an inner axial-jointed portion (the endopodite), which may perhaps be regarded as homologous with the endopodite of the Decapod maxillipede, and also with the thoracic legs of the lobster. This also corresponds to the endopodal unjointed portion of the Phyllopod thoracic limb. In the exopodal or respiratory portion (*ex*) the upper part corresponds to the Phyllopod gill, and the double lower portion to the flabellum.

Comparison with the feet of Limulus (Merostomata).—The resemblance between the abdominal legs of Limulus and the thoracic ones of Nebalia is apparent on inspection of Pl. x, figs. 3 and 4. In Limulus the shell flares out widely and the appendages are united in the middle, although separate in embryonic life, so that this is a feature of secondary importance. The point of special interest is that the abdominal feet of Limulus may, as in the thoracic appendages of the *Phyllopoda* and of the *Phyllocarida*, or the maxillæ, maxillipedes, and thoracic feet of the Decapoda, be divided into an inner endopodal portion (whether ambulatory or natatory), and an outer or respiratory portion, as in *Nebalia* and Decapoda. The endopodite of Limulus (*en*) is axially-jointed, there being three well marked joints to this part of the limb. The branchiate portion of the limb (*ex*) is homologous with that of Nebalia, and the epipodital or branchiate portion of the Decapod thoracic limb. At the same time that of Limulus presents some remarkable peculiarities, *i. e.*, the exopodal (or epipodital)

PLATE X.

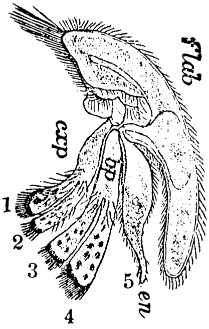


Fig. 1.

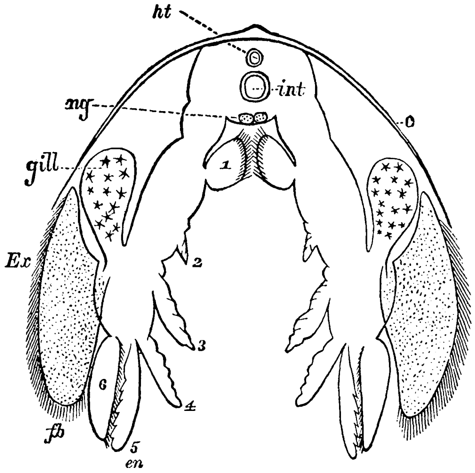


Fig. 2.

FIG. 1.—Maxilla of lobster with its five lobes (1–5) corresponding to the endites of the Phyllopod thoracic limb. FIG. 2.—Section through the thorax of Apus: *en*, 1–6, the six endites; *ex*, exopodal or respiratory portion of the limb; *c*, carapace.

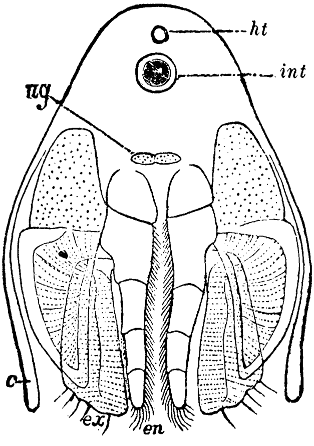


Fig. 3.

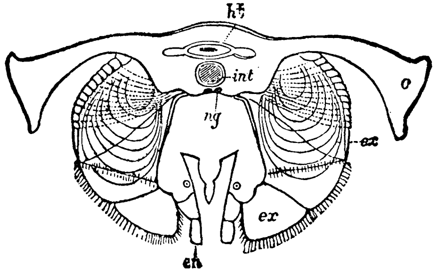


Fig. 4.

FIG. 3.—Partly diagrammatic section through the thorax of Nebalia; *en*, the axial-jointed endopodite; *ex*, exital portion or gill (above irregularly dotted) and flabellum below with rows of dots; *c*, carapace.

FIG. 13.—Actual section through the abdomen of Limulus: *c*, carapace; *ht*, heart; *int*, intestine; *ng*, ganglia (lettering being the same as Fig. 3); *en*, axial-jointed endopodite; *ex*, exital or respiratory portion bearing the gill-lamellæ; the outer division (*ex*) homologous with the exopodal portion of the Phyllopod and Phyllocaridan appendage.

HOMOLOGIES OF THE CRUSTACEAN LIMB.

portion is jointed; and the gill, instead of being a simple, fan-like extension, as in the Phyllopoda and Phyllocarida, is replaced by a number of flat, thin gill-plates, arranged parallel to each other, in an antero-posterior sense. When, however, we compare the gill, or rather the epipodital portion of the leg of Limulus, with that of the lobster, we have the various fundamental elements, *i. e.* an artery and a vein passing into the foot and in connection with a number of gill-plates. In the lobster we have along the base of the gill (Fig. 9), collective veins and an artery into which the blood passes after being aerated in a large number of cylindrical gill-filaments. Morphologically there is a fundamental resemblance between the two types of branchiæ; in Limulus there are gill-plates, in Decapods gill-filaments, each presenting in the aggregate a large respiratory surface. The gills of the Isopoda are in some degree intermediate between the Decapods and the Merostomata.

When we compare the anterior or cephalic appendages with the thoracic appendages of the lobster, there is a close resemblance in the axially-jointed endopodite (Fig. 10, *end*) of Limulus with its large terminal claw to the foot of the Decapod. The absence of the gill or branchiate (epipodital) portion in Limulus is correlated with the ambulatory nature of its anterior or cephalic appendages.

In the trilobites, however, as may be seen by Mr. Walcott's able restoration (Fig. 12), we have attached to the thoracic ambulatory feet a respiratory epipodital portion. In some respects, then, in the trilobites we have a style of structure intermediate between the Merostomata and the Decapoda.

In the trilobite we apparently have, besides a true-jointed locomotive endopodite (Fig. 12, *en*), an inner jointed appendage (*en'*), which may be homologized with the exopodite of the Decapod maxillipede (Fig. 9). From near its base arises the two singular spiral gills, which are unique. It is to be observed that the two jointed appendages and the stem of the gills arise from what appears to be a true coxopodite, and that this coxopodite is apparently homologous with that of Limulus (Fig. 10). It thus appears that a study of the general internal anatomy and of the appendages of the normal, recent Crustacea (*Neocarida*) throws light upon the structure of the archaic Crustacea (*Palæocarides*), and that the most archaic Neocarida, the Phyllocarida (Nebalia), as regards their thoracic limbs, do not remotely resemble the abdominal limbs of Limulus. In this connection we would draw attention to Fig. 11, which is designed to show the possible relations between Limulus and Calymene, or the Merostomata and the Trilobita. The essential difference is in the nature of the limbs; the thoracic limbs of trilobite, while having a jointed endopodite as in Limulus, also having an exopodite and a forked spiral gill. Now, if we append to the coxopodite of Limulus an exopodite, and instead of having the gills arranged anteroposteriorly, like the leaves of a book, have them arranged on one side

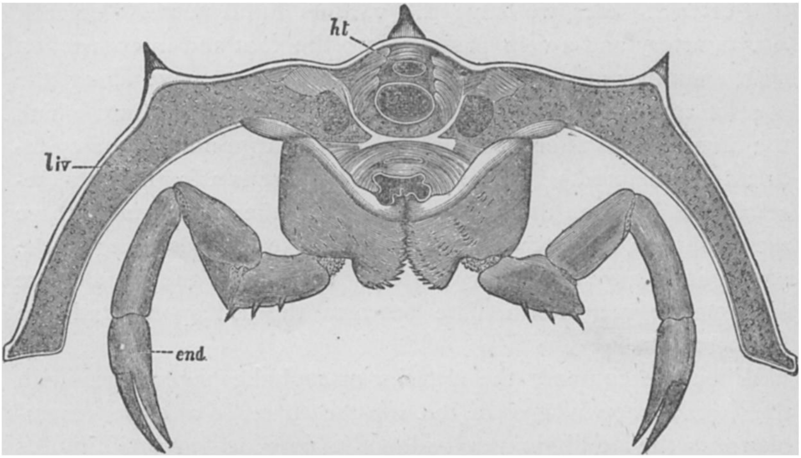


FIG. 10.—Actual section through the head of Limulus, showing the second pair of appendages and their relation to the shell or carapace: *ht*, heart; *liv*, liver; *end*, appendage homologous with the endopodite of Decapoda.

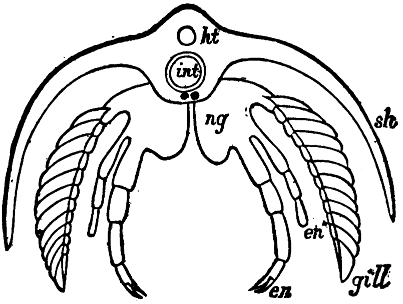


Fig. 11.

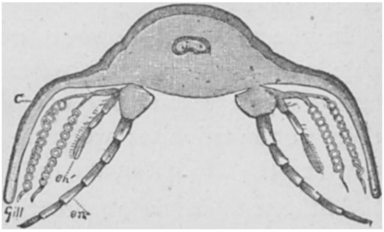
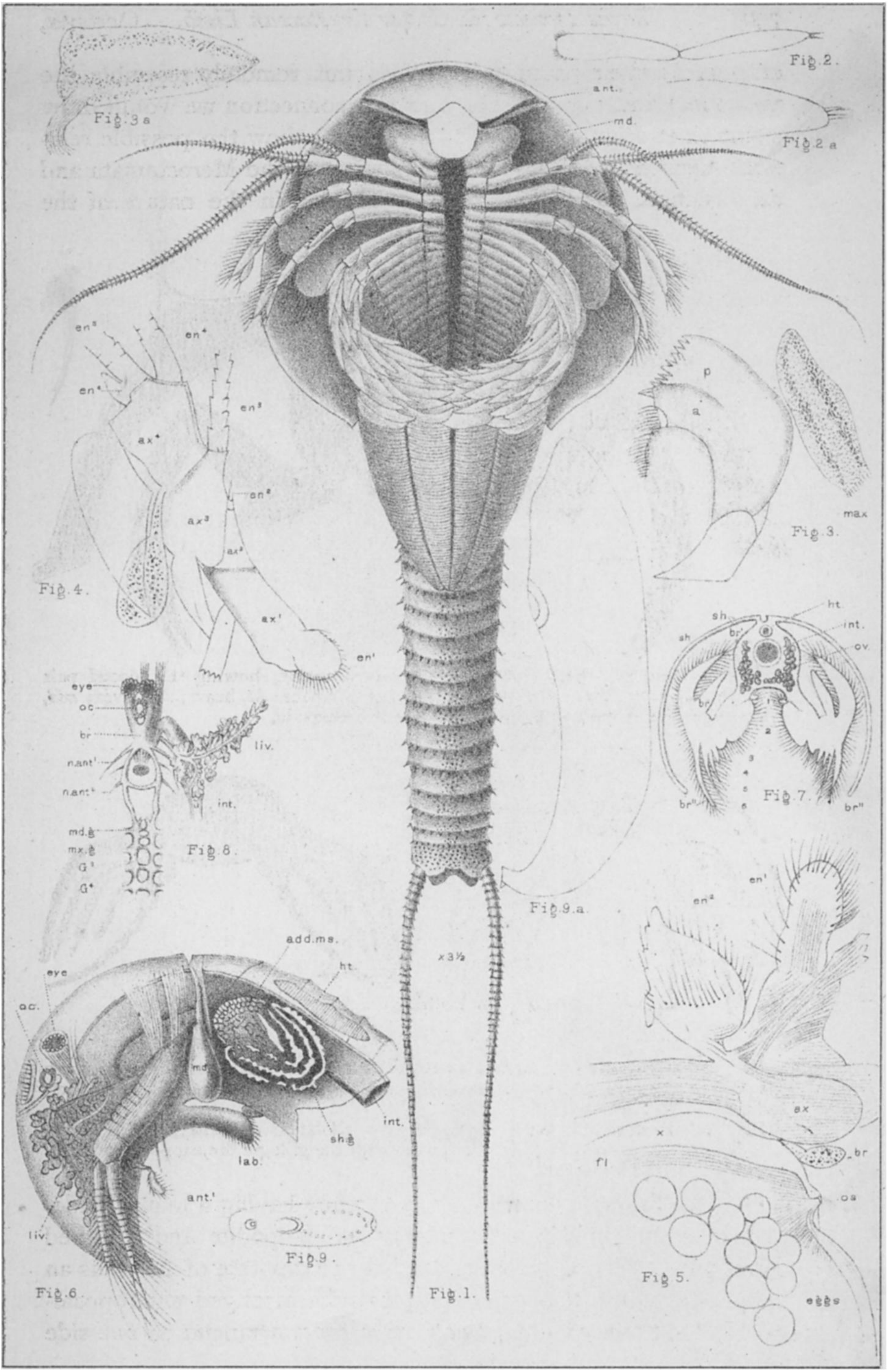


Fig. 12.

FIG. 11.—Diagrammatic section through body of a hypothetical form to show the possible homologies between the appendages of Limulus and a trilobite; the lettering as in Fig. 16.

Fig. 12.—Restored section of the thorax of a trilobite (Calymene), after Walcott: *c*, carapace; *en*, endopodite; *en'*, exopodite with the gills on the exopodal or respiratory part of the appendage.

Plate XI



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ANATOMY OF APUS.

(the outer) of a more or less cylindrical epipodite, as we have drawn them in Fig. 11, we shall hardly be doing greater violence to nature than we see to occur in any Decapod, where, as may be seen in Pl. x, the maxillæ of the lobster have no specialized exopodite, such as is so well marked in the maxillipedes, and the thoracic legs possess not even the rudiments. Change of function and radical changes of structure are most extreme in the Malacostracous Crustacea, from the Brachyura to the Isopoda and Amphipoda. If so startling in these comparatively recent forms, it is not to be wondered at that still greater and more fundamental modifications of the Crustacean type obtain in the archaic forms, the Palæocarides, of which Limulus is the sole survivor. To those who insist on the Arachnidan affinities of the Merostomata, we would suggest that the same shifting and change of function and structure is to be observed among the Tracheate Arthropoda, and that Limulus is not less a genuine Branchiate Arthropod for presenting some features analogous to the Arachnida.

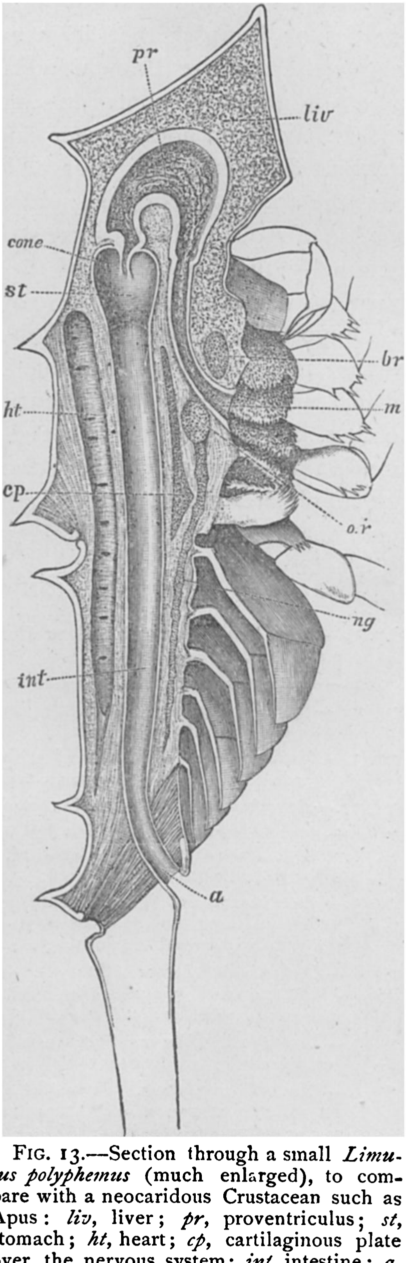


FIG. 13.—Section through a small *Limulus polyphemus* (much enlarged), to compare with a neocaridous Crustacean such as Apus: *liv*, liver; *pr*, proventriculus; *st*, stomach; *ht*, heart; *cp*, cartilaginous plate over the nervous system; *int*, intestine; *a*, anus; *br*, brain; *m*, mouth; *or*, œsophageal ring; *ng*, abdominal ganglia.

A study of the Phyllopoda and Phyllocarida must tend to confirm the view we have expressed as to the synthetic or generalized nature of Limulus. While we have in another place endeavored to show in the light of A. Milne-Edwards' anatomical studies on Limulus, that it is an abnormal Crustacean and far removed from the Branchiopoda; there are nevertheless some points in which it comes in contact with the Phyllopoda, and which have been noticed ever since the time when O. F. Muller comprised Apus in his genus "*Limulus.*" If the reader will compare the accompanying longitudinal section of Limulus with our section of Apus in Pl. XI, some striking resemblances will be seen; externally the front edge of the carapace, *i. e.*, the frontal doublure, so well adapted for burrowing in the mud; the relations of the hypostoma or labrum, and the retention of the ocelli, as well as the mode of molting the shell, are external points of resemblance, while internally the front part of the head filled with the lobules of the liver, the oblique long narrow, œsophagus, the position of the stomach under the eye so far in front in the head, the simple archi-cerebrum, the general form of the heart, and the gnathobases near the mouth are additional points of resemblance.

EXPLANATION OF PLATE XI.

FIG. 1.—*Apus lucasanus* Pack. Seen from beneath. Enlarged 3½ times. *md*, mandibles.

" 2.—*Apus lucasanus* Pack. First antennæ.

" 2*a*.—*Apus lucasanus* Pack. End of the same magnified. The antennæ of both pairs drawn to the same scale.

" 3.—*Apus lucasanus* Pack. Maxilla, showing the (*a*) anterior and (*b*) posterior divisions of the free edge; *max*, the gill of the maxillipede.

" 3*a*.—*Apus lucasanus* Pack. Maxillipede, represented by the gill only.

" 4.—*Apus lucasanus* Pack. First leg giving (with some changes) Lankester's nomenclature of the parts; ax^1–ax^4, the pseudojoints; en^1–en^6, the six endites, with the gill and flabellum.

" 5.—*Apus lucasanus*. The oostegite, or part of the 11th pair of legs of the female containing the eggs; *os*, aperture of the sack; *fl*, modified flabellum; *x*, the greatly enlarged subapical lobe; *br*, the gill.

" 6.—*Limnetis brachyura* (Europe). ant^1, 1st antennæ; ant^2, 2d antennæ; *lab*, labrum; *sh. g*, shell gland; *int*, intestine; *ht*, heart; *add, ms*, adductor muscle; *oc*, ocellus; *md*, mandible; *liv*, liver.

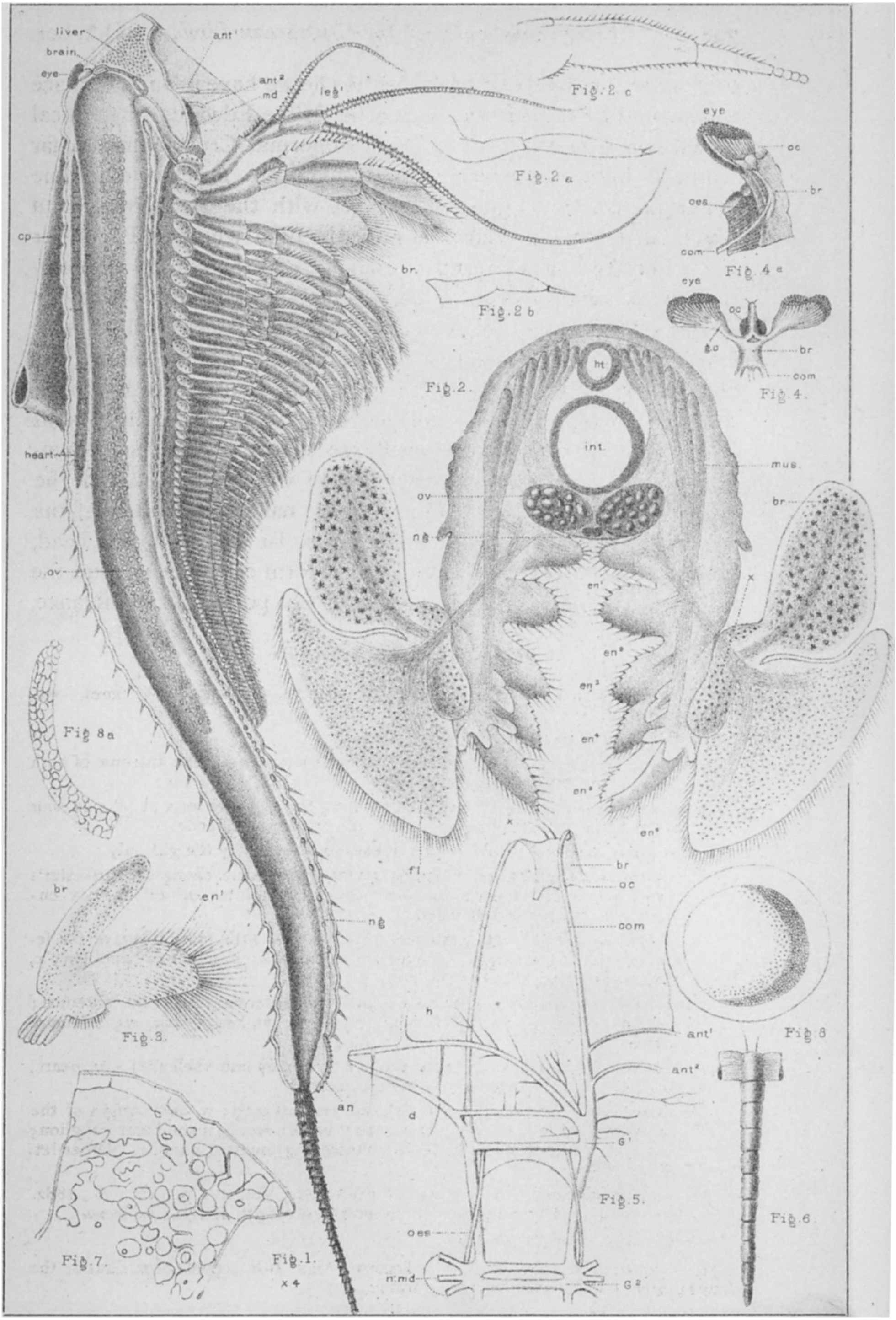
" 7.—*Limnetis brachyura*. Section through the body and shell (*sh*); *ht*, heart; *int*, intestine; *ov*, ovary; 1–6, the six endites.

" 8.—*Limnetis brachyura*. Brain (*br*) and nervous cord; *n.* ant^1, origin of the 1st antennal nerve; *n.* ant^2, 2d antennal nerve; *md. g*, mandibular ganglion; *mx. g*, maxillary ganglion; G^1, G^2, succeeding thoracic ganglia. Other letters as in Fig. 7.

" 9.—*Distomum apodis* Pack. AMER. NATURALIST, Vol. XVI, p. 142, Feb., 1882. Side view, greatly enlarged. A parasite in oostegite of *Apus lucasanus*.

" 9 *bis*. The same, ventral view.

Fig. 1 drawn from nature by J. S. Kingsley; Figs. 6–8 copied from Grube; the others drawn with the camera by the author.



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EXPLANATION OF PLATE XII.

FIG. 1.—*Apus lucasanus* Pack. Section through the body, with the intestine removed. *md*, mandible; *ant*^{1}, *ant*^{2}, 1st and 2d antennæ; *leg*^{1}, first pair of legs; *br*, flabellum; *ov*, ovary; *ng*, ganglionic chain.

" 2.—Transverse section through the body at the 7th or 8th pair of feet, the shell removed, *mus*, dorso-ventral adductors of the feet, crossed by the adductors of the exites; *ht*, heart; *int*, intestine; *ov*, ovary; *n. g*, ventral ganglion; *en*^{1}-*en*^{6}, endites; *br*, gill; *fl*, flabellum; *x*, subapical lobe.

" 2*a*.—1st antenna; 2*b*, 2d antenna; 2*c*, the extremity of 2d antenna, with four bead-like joints, showing the three imperfect joints, the third ending in a moniliform portion.

" 3.—Maxillipede with the gill (*br*) and single endite.

" 4, 4*a*.—Dorsal and lateral view of the brain of the European *Apus cancriformis*; *br*, brain; *com*, commissure to subœsophageal ganglion; *g. op*, optic ganglion; *oc*, ocellus; *œs*, œsophagus.

" 5.—Brain and part of ventral cord of *Apus cancriformis*; *oc*, nerve to ocelli; *ant*^{1}, *ant*^{2}, first and second antennal nerves; G^1, œsophageal; G^2, mandibular ganglion, sending off three mandibular nerves (*n md*); *d*, descending œsophageal nerve; *h*, unpaired or lower œsophageal ganglion; *œs*, nerve passing to the muscles of the œsophagus.

" 6.—Heart of *Apus cancriformis*.

" 7.—*Apus longicaudatus*, portion of embryonic membrane lying next to the chorion, and supposed to represent the amnion in Limulus; the nuclei in many of the cells have become absorbed.

" 8.—An egg of the same, showing the cellular nature of the amnion.

" 8*a*.—A portion of the same amnion seen sideways of the egg.

Fig. 1 drawn under the author's direction by J. S. Kingsley; Figs. 4, 4*a*. 5 and 6 copied from Zaddach; the remainder drawn with the camera by the author.

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IDOLS AND IDOL WORSHIP OF THE DELAWARE INDIANS.

BY CHARLES C. ABBOTT.

JOHN Brainerd, while a missionary among the Indians of New Jersey, recorded of one of these people, that "she had an aunt * * * * who kept an idol image, which, indeed partly belonged to her, and that she had a mind to go and fetch her aunt and the image, that it might be burnt; but when she went to the place she found nobody at home, and the image also was taken away." While this, indeed, is slender evidence of the occurrence of idol worship among the Delaware Indians, it is of interest in showing that images were not unknown, and that they possessed other significance and value than as mere ornaments. Any carving in wood or stone, merely used for personal decoration would not have become sinful in the mind of an Indian woman, through the preaching of the missionary; and a desire to destroy the object she reported as in her possession, must necessarily have